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*Research and
Development
Report*

**THE SOUND INSULATIONS
OF STUDIO DOORS:
Part 1: Door Blanks**

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**Research and Development Department,
Engineering Division
THE BRITISH BROADCASTING CORPORATION**

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Summary

The sound insulations of a range of different door blanks were measured. The results were compared with the sound insulations of existing BBC door blanks. The new doors were made from medium density fibreboard (MDF) which is more stable than the blockboard used in existing studio doors. Consequently, they should require less maintenance and adjustment and should have a longer lifespan. The doors had higher sound insulations for their weight than existing designs, which might permit savings in the costs of the surrounding building structures. Overall construction costs of the door blanks themselves are likely to be similar to those of existing designs.

A companion Report (BBC RD 1994/15) describes sound insulation measurements made on plant-on door seals. The intention of this work was to simplify the construction of the door frame and the fitting of the seals to reduce costs.

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1. INTRODUCTION

Existing solid-cored BBC studio doors consist of two pieces of 25 mm thick blockboard glued and screwed together. BBC lead-cored doors are similar except that a 2.5 mm thick layer of lead sheet is inserted between the layers of blockboard. The doors are finished in veneer and have a machined hardwood lipping fixed to the edges.

Recently, a new polymer-cored door has been used in some Scottish studios. The door consisted of a sheet of 2.5 mm thick lead-loaded polymer sheet (approximate density 3 kg/m²/mm) between two layers of 18 mm thick MDF (medium density fibreboard) finished with a layer of 6 mm thick birch-faced plywood each side.

BBC doors made from blockboard are prone to warping. MDF is more stable and easier to work with than blockboard. Thus doors constructed from MDF should require less adjustment and should have a longer lifespan as well as being marginally easier to manufacture. The lead-cored door is particularly heavy and it would be worthwhile to find a way of reducing its weight without compromising the sound insulation. For the work described in this Report, two types of MDF door construction were investigated: firstly, solid-cored doors and secondly, air-cored doors.

To reduce costs, it would be possible to use a softwood frame rather than the present hardwood frame. However, this would probably reduce the overall fire rating of the doorway¹ which would be unacceptable in some situations. It was desirable to maintain the ½ hour fire rating of existing BBC doors.

Proprietary doors were not tested for a number of reasons: the majority of the proprietary doors are either more expensive, not available in suitable sizes or do not have adequate acoustic performances. It was also considered undesirable to be dependent on one manufacturer, because of potential instability of cost, long term supply and difficulties with delivering to all regions of the BBC. Some of these manufacturers publish the results of ISO-Standard Transmission Suite measurements of the sound insulations of their doors. If, for any reason, a proprietary door was required in preference to those described in this Report, the selection should be based on a comparable, or at least adequate, sound insulation performance.

To test the door blanks, it was necessary to build a substantial masonry wall between the source and receive rooms of the Transmission Suite into which the doors could be fitted. The test partition is described in Appendix I. Appendix II describes measurements performed to determine the optimum sealing method for the door blanks. The door blanks (size 2.02 m × 0.95 m) were sealed with acoustic sealant into a door frame constructed in an opening (size 2.1 m × 1.055 m) in the test partition. Results were compared against those for the existing BBC solid-cored and lead-cored acoustic doors.

Doors installed in BBC studios are usually lipped with hardwood and faced with veneer. For the tests described in this Report, only the solid-cored, lead-cored and polymer-cored doors were finished in this fashion. The other blanks had no lipping or veneer. However, it was not envisaged that the finishing detail would significantly affect the measured sound insulations.

2. SOLID-CORED DOOR BLANK TESTS

MDF is considerably denser than blockboard. A door comprising a layer of 2.5 mm thick lead sheet surrounded by 25 mm MDF and finishing sheets on each side would be too heavy in most circumstances. Therefore a variety of 30 mm thick door blanks were used to identify the factors that determine the achieved levels of sound insulation. The expected outcome of the tests was a design for a 50 mm thick composite door based on MDF which would have good sound insulations and have a reasonable weight. Unless otherwise stated, all boards were glued and screwed together. The following sections detail a variety of tests performed to determine the factors which control the achieved levels of sound insulation. The intention was to optimise the solid-cored door construction. Fig. 1 (*overleaf*) shows the symbols used for the different door materials shown in the keys to the graphs in this Report.

2.1 Standard BBC door blanks

Fig. 2 (*overleaf*) shows the measured sound insulations of existing BBC door blanks (all subsequent references to BBC doors relate to these existing designs rather than any of the new designs described later). The polymer door, as used in some

Scottish studios, consists of 6 mm plywood – 18 mm MDF – 2.5 mm lead-loaded polymer – 18 mm MDF – 6 mm plywood. The lead-loaded polymer had an approximate density of $3 \text{ kg/m}^2/\text{mm}$ (bitumen damping mat has a density of $2 \text{ kg/m}^2/\text{mm}$ and lead has a density of $11.4 \text{ kg/m}^2/\text{mm}$).

The solid-cored door had a particularly poor performance. This is not explicable in mass terms alone. There is a possible shallow coincidence dip² between 500 Hz – 1 kHz which may explain some of the shortfall. The poor performance may also be linked with an unfavourable combination of mass and stiffness. The performance was comparable to that of a 30 mm thickness of plywood (see Section 2.3), which is lighter.

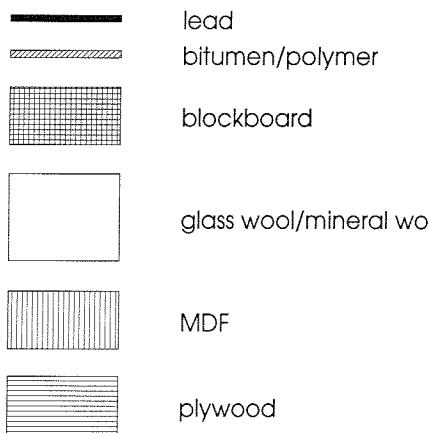


Fig. 1 - Symbols for the materials shown in the keys to the graphs.

The polymer-cored door had a lower performance than the lead-cored door between 500 Hz – 2 kHz. Otherwise, the two performances were similar. The MDF and plywood combination in the polymer-cored door resulted in a coincidence dip which was not completely damped by the polymer damping layer. The polymer door was 10 kg lighter than the lead door.

2.2 Fitting observation windows

As an aside, Figs. 3 and 4 show the effects on the measured sound insulations of the installation of observation windows in the polymer-cored and lead-cored doors. The glass was 12.5 mm thick and of area $200 \text{ mm} \times 200 \text{ mm}$. Despite listening tests which showed the windows to be weaknesses, the measured sound insulations were essentially unaltered by the installation of the windows. This was because the area of the window was small compared to that of the door.

2.3 Different materials

MDF and plywood were the two most

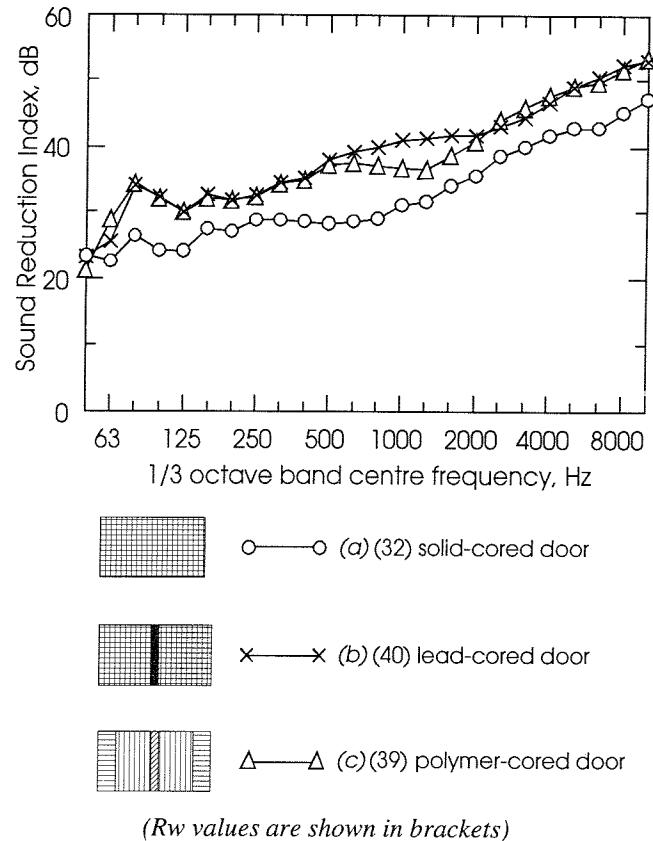


Fig. 2 - The sound insulations of BBC door blanks.

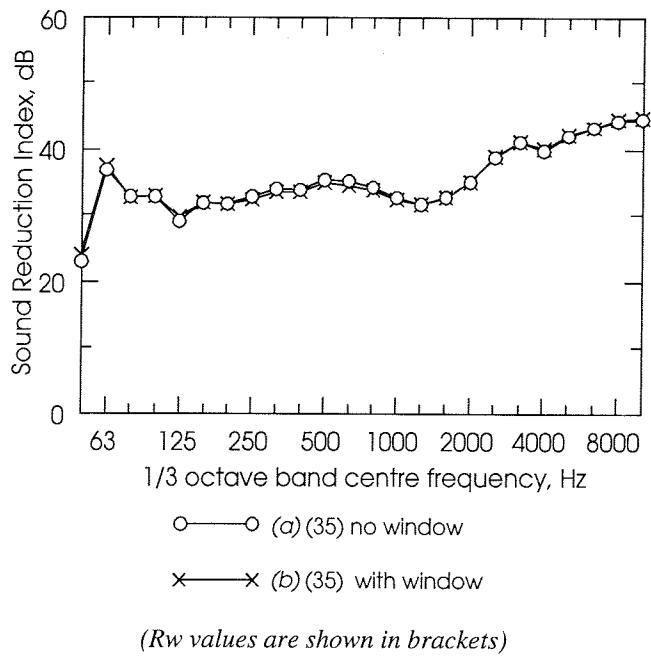
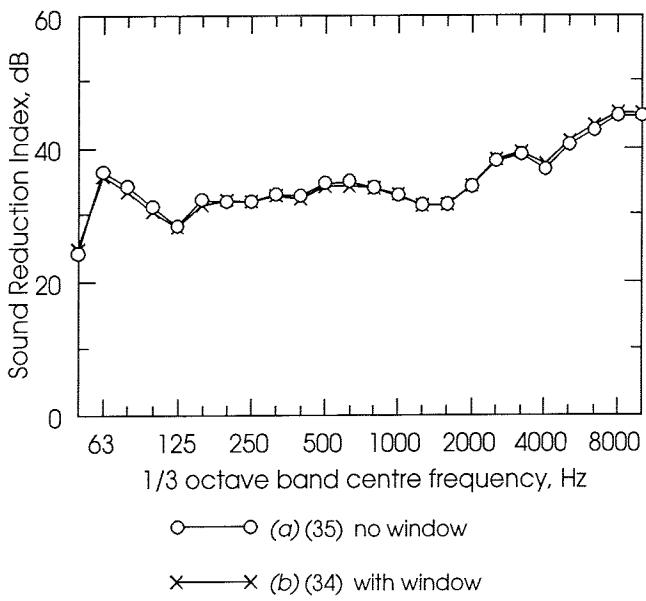


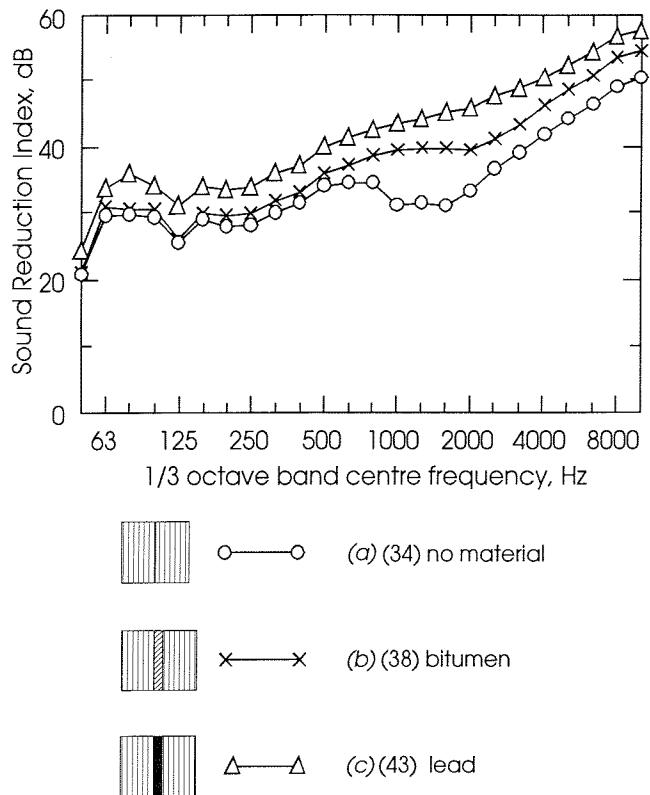
Fig. 3 - The effects of the installation of an observation window on the measured sound insulations of a polymer-cored door.

promising options for new door materials. Blockboard and chipboard were considered undesirable because of their lack of stability. Laminboard and hardwood were rejected on grounds of cost. It was decided not to investigate metal-framed or sand-filled



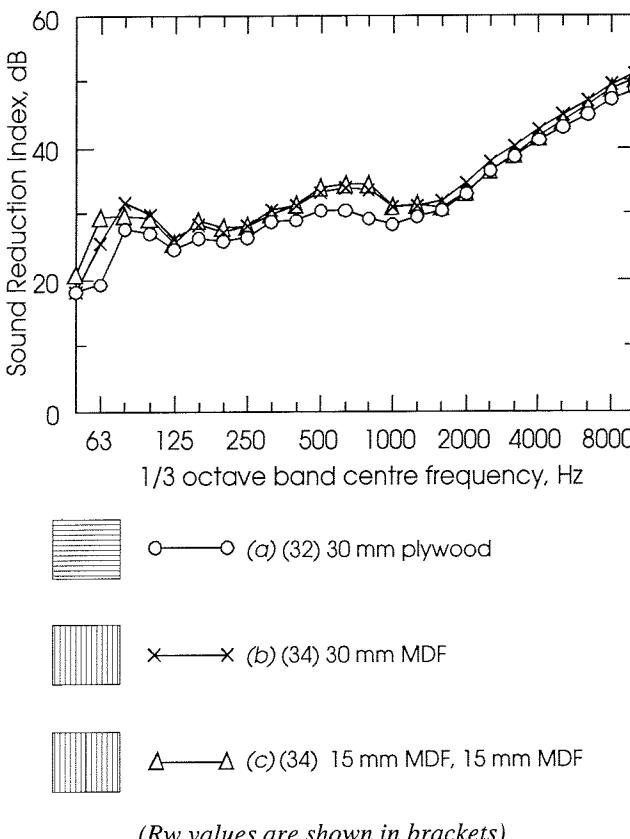
(R_w values are shown in brackets)

Fig. 4 - The effects of the installation of an observation window on the measured sound insulations of a lead-cored door.



(R_w values are shown in brackets)

Fig. 6 - The sound insulations of MDF door blanks having different internal damping materials.
 (15 mm MDF, material, 15 mm MDF)



(R_w values are shown in brackets)

Fig. 5 - The sound insulations of 30 mm thick door blanks made from different materials.

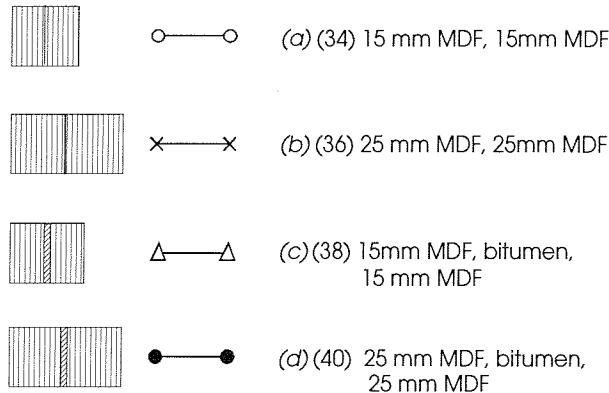
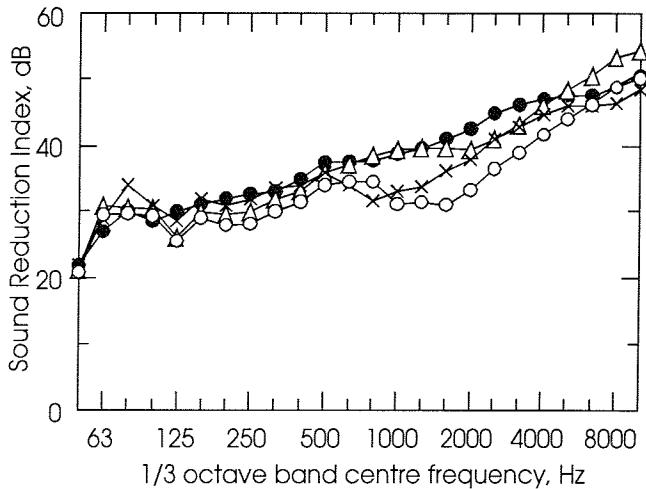
doors as the use of such doors would be such a radical departure from existing door construction methods in the BBC, with no clear benefits.

Fig. 5 shows the measured sound insulations of 30 mm thick plywood and 30 mm thick MDF. The sound insulation curves for the two materials are similar above 1.25 kHz. The coincidence frequency for 30 mm thick MDF is between 1 – 1.6 kHz; for the plywood, it is 1 kHz. Overall, the performance of the plywood is 2 – 3 dB lower than that of the MDF, mainly because of the lower mass of the plywood. Because plywood is also less stable than MDF, it was considered better to use MDF as the base material for the door.

Also shown in Fig. 5 is the effect of using two layers of 15 mm MDF screwed and glued together, rather than one layer of 30 mm thick MDF. The differences between the two results are small, which shows that the two layers act as one.

2.4 Different infills

Fig. 6 shows the effects on the measured sound insulations of the installation of different infills between two layers of 15 mm MDF. With no infill, there was a large coincidence dip between 1 – 1.6 kHz. The installation of a 2.5 mm thick bitumen damping mat smoothed out the coincidence dip which resulted in large increases in the sound insulations at



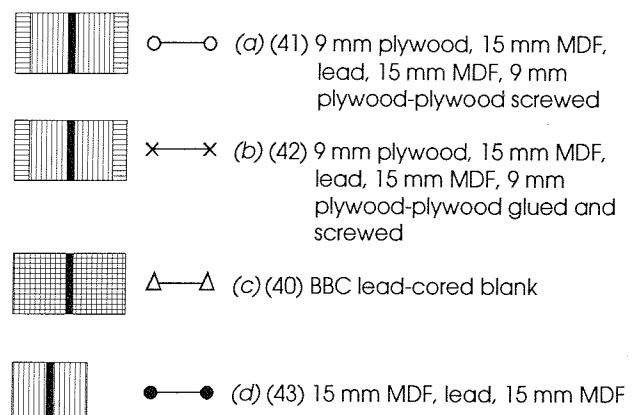
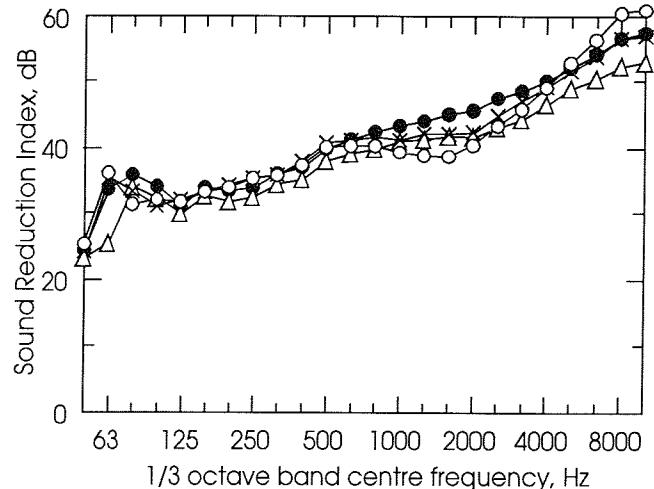
(R_w values are shown in brackets)

Fig. 7 - The effects of the thicknesses of the door blanks on their measured sound insulations.

higher frequencies. The sound insulations at lower frequencies increased because of the additional internal damping and mass. The installation of the 2.5 mm thick lead sheet also smoothed out the coincidence dip and increased the sound insulations at most frequencies by 5 dB, as predicted from the mass law.

2.5 Different thicknesses

Fig. 7 shows the effects on the measured sound insulations of increasing the thicknesses of the MDF doors. Measurements were made with and without the bitumen damping mat installed in the blanks. The effects of the installation of bitumen were described in Section 2.4. The coincidence frequency for 30 mm MDF is at a frequency somewhere in the range 1 – 1.6 kHz (the coincidence dip is shallow so it is difficult to determine the coincidence frequency accurately). The coincidence frequency for 50 mm MDF is 800 Hz. Without bitumen, the differences between the results for the 30 mm and 50 mm thicknesses at higher frequencies are controlled by wave coincidence effects. The differences between the



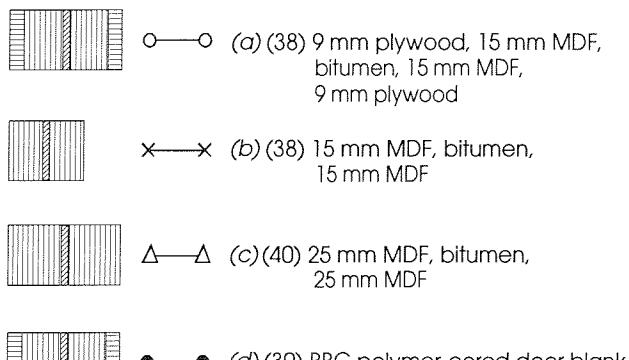
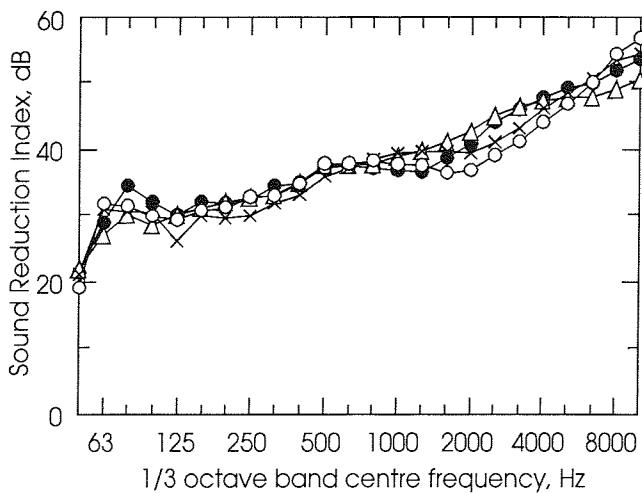
(R_w values are shown in brackets)

Fig. 8 - The sound insulations of lead-cored door blanks.

results for the 30 mm and 50 mm thicknesses at lower frequencies are approximately 3 dB, because of the mass difference. With bitumen installed, the differences between the curves that are caused by the thickness change were less pronounced. This was because the overall levels of damping in the 30 mm and 50 mm blanks were different.

2.6 Lead-cored composite doors

Fig. 8 shows the measured sound insulations of two lead-cored composite door blanks together with those of other lead-cored door blanks. The lead-cored composite door blanks were constructed from plywood, MDF and lead sheet. The performance of the BBC lead-cored door was worse, between 50 – 63 Hz, 125 – 800 Hz and 3.15 – 10 kHz, than that of the blank consisting of a layer of lead sandwiched between two layers of 15 mm MDF. This MDF door had a similar mass to that of the BBC door, so the different performances must be linked with different stiffness or damping properties (the MDF door was less stiff than the BBC lead door).



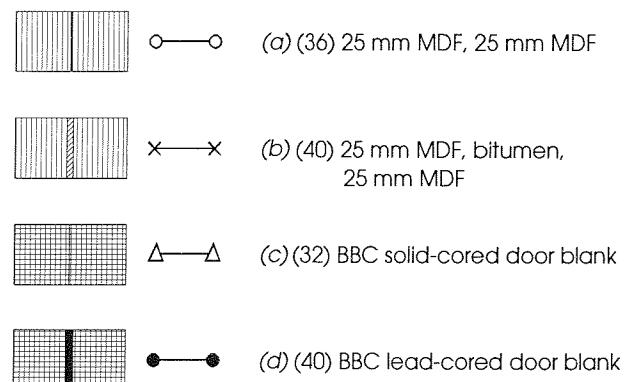
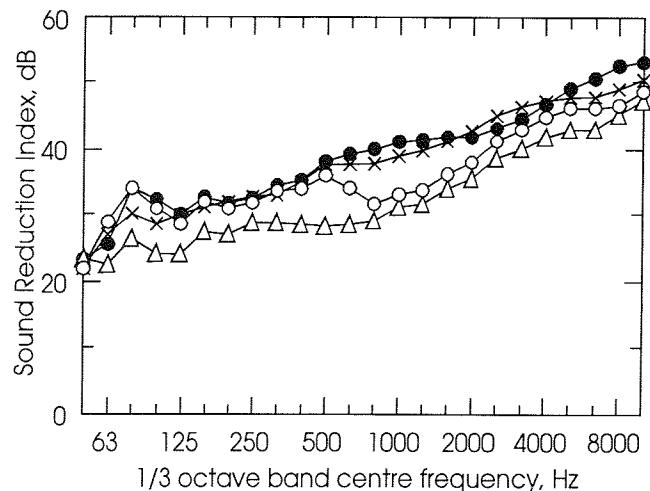
(Rw values are shown in brackets)

Fig. 9 - The sound insulations of bitumen-cored door blanks.

The addition of plywood to the MDF door reduced the sound insulations above 800 Hz. The plywood altered the stiffness and internal damping of the door and affected the depth of the coincidence dip. These thicknesses of plywood and MDF have similar coincidence frequencies and they do not damp each other very well. Gluing and screwing the boards together reduced the depth of the coincidence dip because it forced the boards to act together more strongly. The lead-cored composite door was too heavy and expensive in relation to the levels of sound insulation provided.

2.7 Bitumen-cored composite doors

Fig. 9 shows the measured sound insulations of a bitumen-cored composite door blank together with those of related door blanks. The composite door contained plywood, MDF and a bitumen damping mat. Fitting the plywood increased the sound insulations between 125 – 500 Hz by approximately 2 dB, because of the extra mass. Above 800 Hz, the measured sound insulations decreased because of wave coincidence effects. The coincidence frequencies of the thicknesses of MDF and plywood used were



(Rw values are shown in brackets)

Fig. 10 - The sound insulations of the best bitumen-cored door blank.

similar to each other and the two coincidence dips combined to give a dip which could not be fully damped by the bitumen damping mat. The performance of the door consisting of a layer of bitumen damping mat sandwiched between two layers of 25 mm thick MDF was better than that of the composite door, in the frequency range where coincidence dips occur. However, the composite door weighed less.

The overall performance of the BBC polymer-cored door blank was comparable to that of the composite door. However, the coincidence dip for the polymer door was not so deep. This may be because of differences in the grades and thicknesses of boards used or because the polymer mat is better at damping than the bitumen mat. The polymer mat was said to be lightly lead-loaded, although the manufacturer of the door was unable to supply details of the material used.

The solid-cored door blank having the best compromise of weight, cost and sound insulation was that consisting of a layer of a bitumen damping mat sandwiched between two layers of 25 mm MDF. Fig. 10 shows the measured sound insulations of this

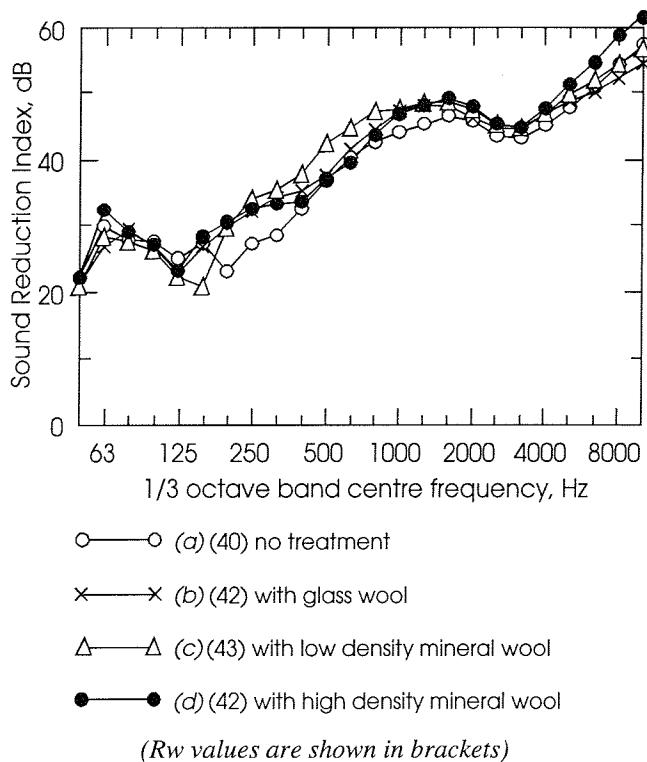


Fig. 11 - The effects of internal acoustic treatment on the sound insulations of the lightweight door blank.

(12 mm MDF, bitumen, 25 mm cavity, 12 mm MDF)

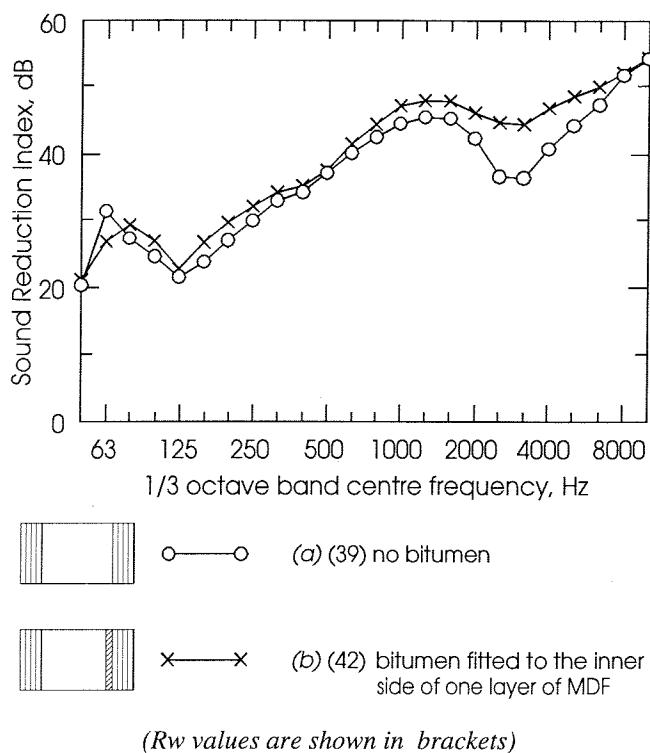


Fig. 12 - The effects of the installation of bitumen damping mat in the lightweight door blank on its measured sound insulations.

(12 mm MDF, 25 mm glass wool, 12 mm MDF)

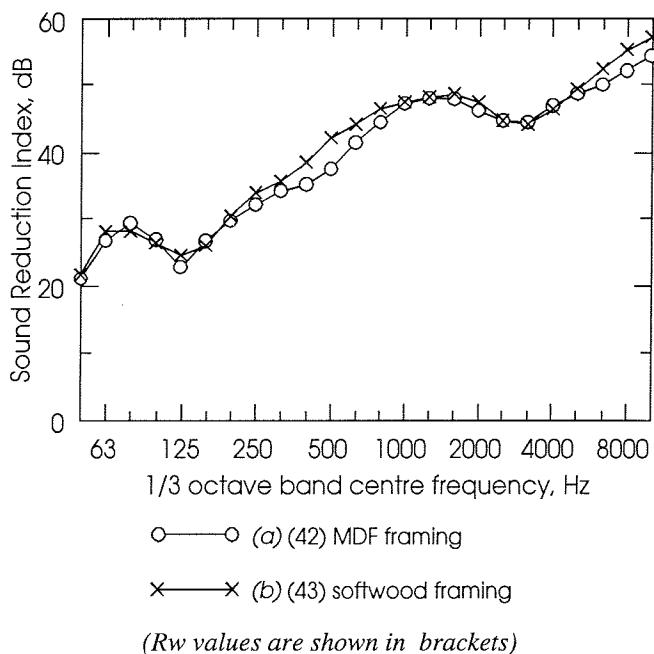


Fig. 13 - The effects of the perimeter framing on the measured sound insulations of the lightweight door blank.

(12 mm MDF, bitumen, 25 mm glass wool, 12 mm MDF)

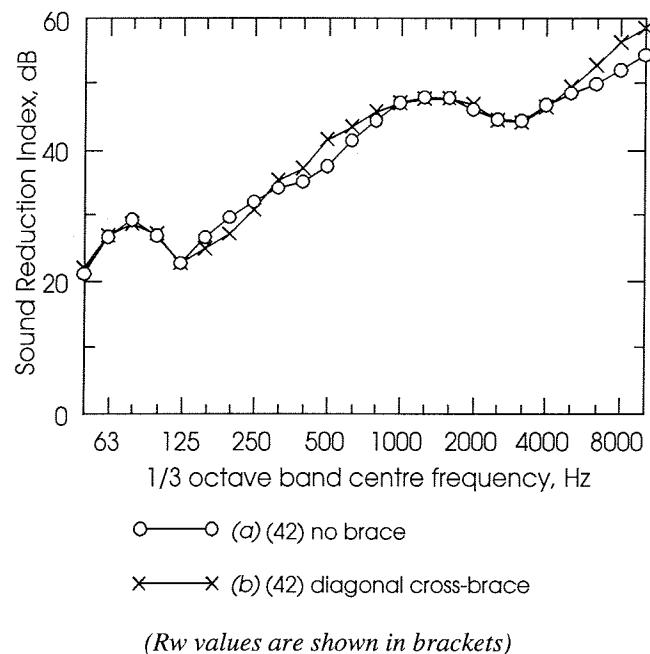


Fig. 14 - The effects of the installation of an internal diagonal cross-brace on the measured sound insulations of the lightweight door blank.

(12 mm MDF, bitumen, 25 mm glass wool, 12 mm MDF)

door blank together with those of other door blanks. The bitumen-cored door had a sound insulation performance comparable with that of the standard BBC lead-cored door, but it was lighter, more stable and cheaper. The installation of a bitumen damping mat between the two layers of 25 mm MDF removed the deep coincidence dip centred on 800 Hz. The BBC solid-cored door has a performance considerably lower than those of the other doors shown.

3. AIR-CORED DOOR BLANK TESTS

The following sections describe a number of sound insulation measurements performed on different types of lightweight air-cored door. The intention was to design a door that had a high level of sound insulation for its weight. The door typically consisted of one layer of MDF either side of a 25 mm cavity. The boards were spaced by 25 × 50 mm battens at the perimeter of the door.

3.1 Internal acoustic treatment

Fig. 11 shows the effects of acoustic treatment in the cavity of the lightweight door on the measured sound insulations. With no treatment installed in the cavity, the sound insulations between 200 – 315 Hz were poor because of a mass-air-mass resonance³ between the two boards.

The addition of acoustic treatment generally increased the insulations at most frequencies because the motions of the boards were damped and because sound that had leaked into the cavity was absorbed. The performances of the doors containing glass wool and high density mineral wool were similar to each other. The door containing low density mineral wool had a dip in its sound insulation curve at 160 Hz, but its performance was better between 250 – 800 Hz.

The addition of acoustic treatment moved the dip at 200 Hz, caused by a mass-air-mass resonance, to 125 Hz. This dip combined with that caused by an existing fundamental panel resonance at 125 Hz. The best compromise of weight, cost and the overall level of sound insulation achieved was provided by the use of glass wool in the cavity.

3.2 Bitumen damping mat

Fig. 12 shows the effects on the measured sound insulations of fitting a bitumen damping mat to one skin of the lightweight door. There was an overall improvement in the measured sound insulations at all frequencies except for 63 Hz. The bitumen damping mat considerably reduced the depth of the coincidence dip at 2.5 – 3.15 kHz.

3.3 Surround framing

Fig. 13 shows the effects of the material used for the perimeter framing in the lightweight door on the measured sound insulations. The measured sound insulations at 125 Hz and between 250 – 800 Hz were greater when the softwood surround frame was installed rather than the MDF frame. This may be because the softwood does not form such a rigid mechanical bridge, or because the softwood frame was fixed to the MDF with screws and acoustic sealant rather than screws and glue. However, the differences were relatively small and may have arisen purely because the door was reconstructed using new materials.

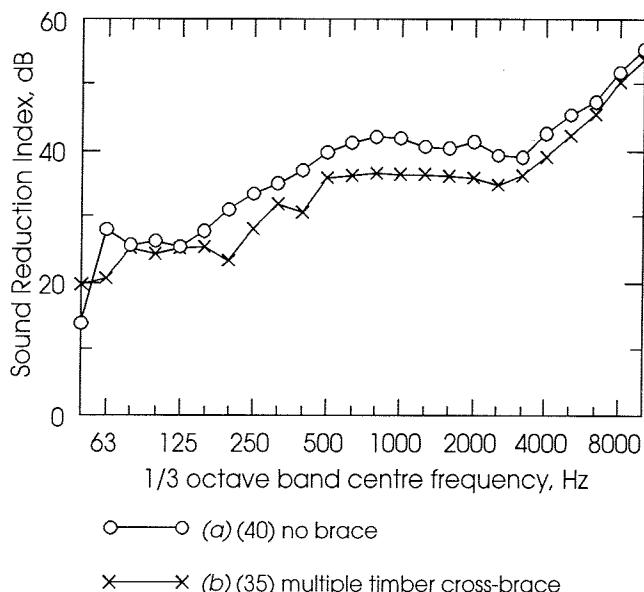
3.4 Internal cross-bracing

Fig. 14 shows the effects on the measured sound insulations of the installation of an internal diagonal cross-brace in the lightweight door (12 mm MDF, bitumen damping mat, 25 mm cavity with glass wool, 12 mm MDF). The brace mechanically coupled the two skins of the door together and was made from 25 m × 50 mm MDF. The brace was intended to reduce the depth of the dip in the sound insulation curve at 125 Hz assuming that the dip was partially linked with fundamental panel resonances in both skins of the door. Unfortunately, the sound insulation at 125 Hz was unaffected. The installation of the brace reduced the measured sound insulations between 160 – 250 Hz, but increased the insulations between 315 – 800 Hz and above 4 kHz.

Fig. 15 (*overleaf*) shows the effects on the measured sound insulations of the installation of an appreciable quantity of internal cross-bracing in a lightweight door (18 mm MDF, 25 mm cavity with glass wool, 9 mm MDF) described in more detail later. The installation of the internal cross-bracing reduced the sound insulations at most frequencies because of the additional mechanical coupling between the two skins of the door. These reductions masked any improvement that might have occurred as a result of damping a fundamental resonance. If a large quantity of cross-bracing were used to increase the strength or stiffness of any of the lightweight doors, it would probably compromise the achieved levels of sound insulation.

3.5 Steel bracing

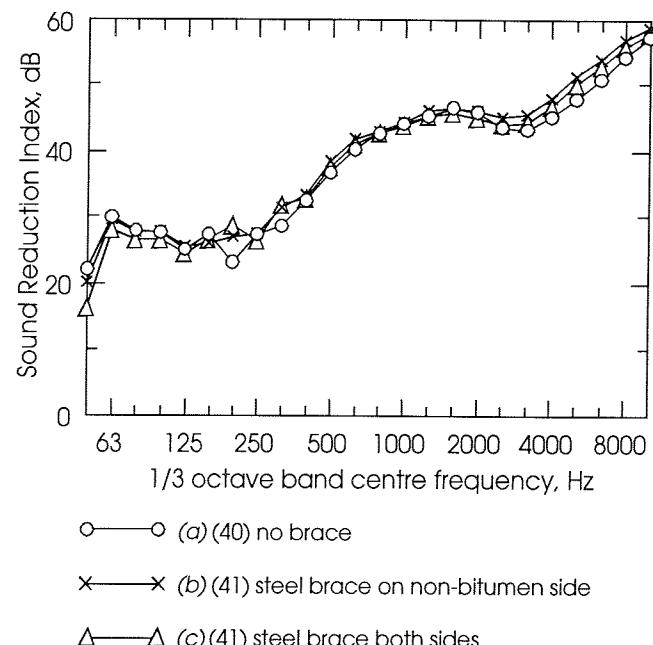
Figs 16 and 17 (*overleaf*) show the effects on the measured sound insulations of the installation of internal steel bracing in the lightweight door (12 mm MDF, bitumen damping mat, 25 mm cavity, 12 mm MDF). The bracing did not couple the two skins of the door together. For the measurements of Fig. 16, the



(Rw values are shown in brackets)

Fig. 15 - The effects of the installation of a large quantity of internal cross-bracing on the measured sound insulations of a lightweight door blank.

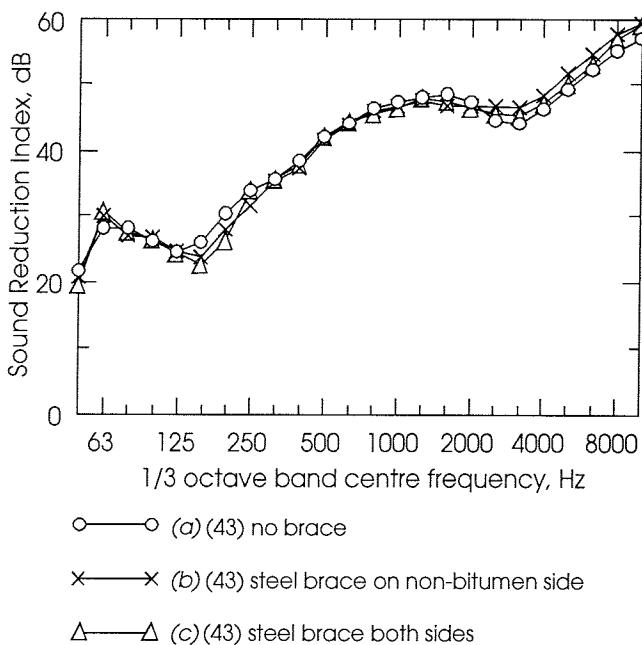
(18 mm MDF, 25 mm glass wool, 9 mm MDF)



(Rw values are shown in brackets)

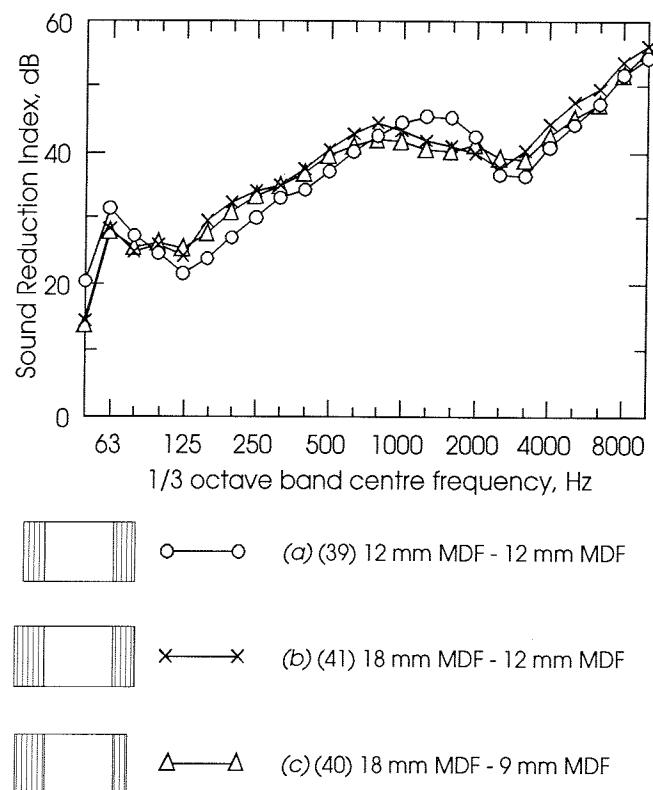
Fig. 16 - The effects of internal steel bracing on the measured sound insulations of the lightweight door blank.

(12 mm MDF, bitumen, 25 mm air, 12 mm MDF)



(Rw values are shown in brackets)

Fig. 17 - The effects of internal steel bracing on the measured sound insulations of the lightweight door blank.
(12 mm MDF, bitumen, 25 mm glass wool, 12 mm MDF)



(Rw values are shown in brackets)

Fig. 18 - The effects of the board thicknesses on the measured sound insulations of the lightweight door blank.
(board, 25 mm glass wool, board)

cavity in the door was untreated and for the measurements of Fig. 17, glass wool was installed in the cavity.

With an untreated cavity (Fig. 16), the effects of the installation of the steel bracing were relatively small. The dip in the sound insulation curve at 200 Hz, linked with a mass-air-mass resonance, was removed by the installation of the steel. When the cavity was treated with glass wool (Fig. 17), the effects of adding the steel bracing were also small. The addition of the bracing reduced the sound insulations between 160 – 250 Hz and there were small effects at higher frequencies. The depth of the dip at 125 Hz was unaffected. The addition of internal steel bracing did not seem to be worthwhile.

3.6 Board thicknesses

Figs. 18 and 19 show the effects of the thicknesses of the boards used in the lightweight door on the measured sound insulations. For the measurements of Fig. 18, no bitumen damping mat was installed in the door. For the measurements of Fig. 19 a bitumen damping mat was secured to the thinner board in the door.

Without a bitumen damping mat installed, the door containing two layers of 12 mm MDF (Fig. 18(a)) had very poor insulations between 125 – 500 Hz, but good insulations between 50 – 80 Hz. The coincidence dip at 2.5 – 3.15 kHz was very pronounced. The coincidence dips for the other two constructions (Fig. 18(b), Fig. 18(c)) were less pronounced because the different board thicknesses tend to counteract coincidence effects. The door made from 18 mm MDF and 12 mm MDF (Fig. 18(b)) had the best performance at most frequencies, because of its greater mass. However, its performance at 125 Hz and between 2.5 – 3.15 kHz was not the best (because of mass-air-mass resonances and coincidence effects). The door made from 18 mm MDF and 9 mm MDF had the optimum performance because the depth of the dip at 125 Hz was critical and because the door was lighter and cheaper than that made from 18 mm MDF and 12 mm MDF.

With a bitumen damping mat installed on the thinner skin (Fig. 19), the 12 mm MDF – 12 mm MDF combination produced the worst sound insulations between 160 – 315 Hz. This time, the 18 mm MDF – 9 mm MDF combination did not have the best performance between 125 – 160 Hz. This is because the addition of bitumen to the 9 mm board alters its mass-air-mass resonant frequency to approximately 125 Hz. (However, the addition of the bitumen to the 18 mm board instead is very worthwhile, of which more later.) The coincidence dip at 1.6 kHz for the

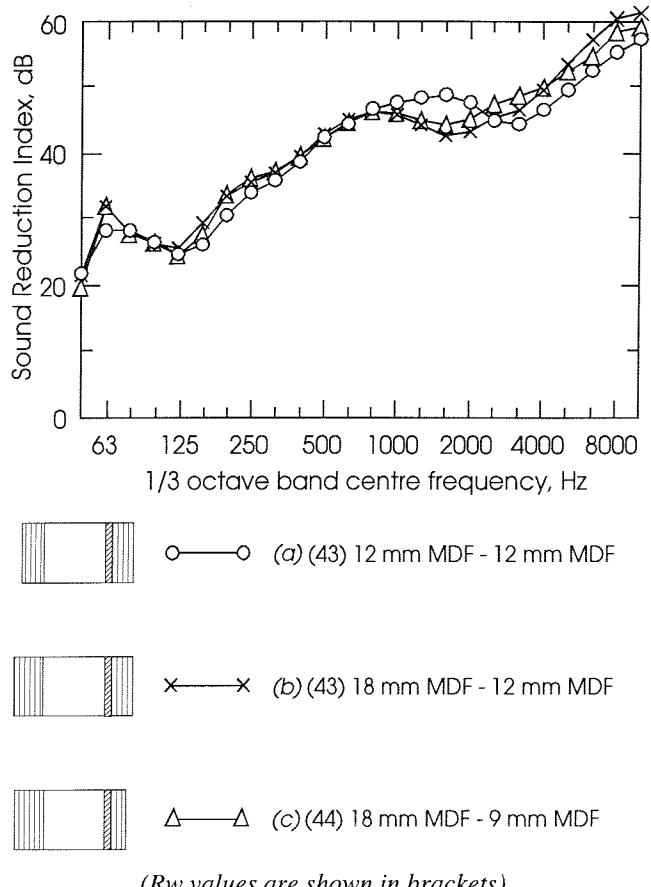
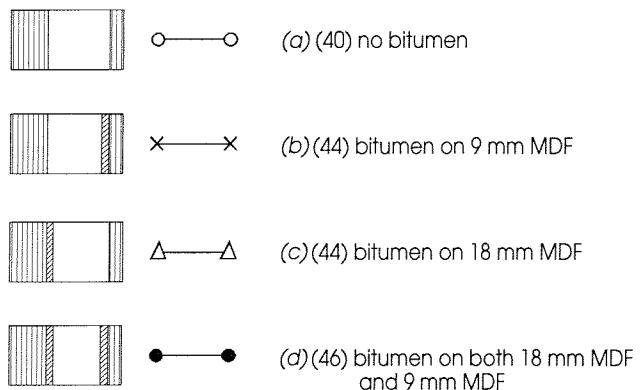
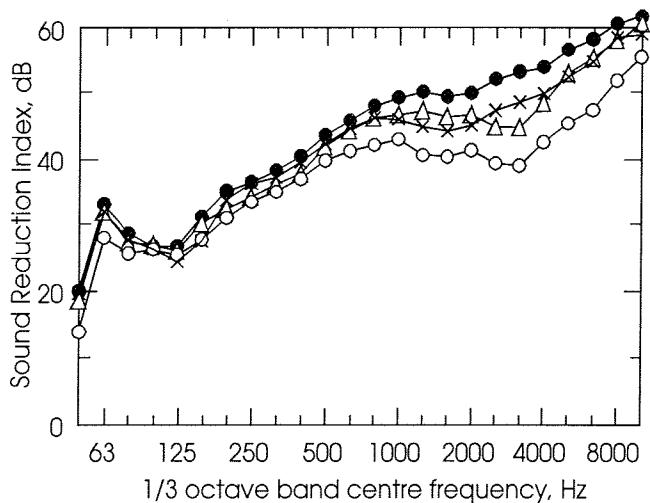


Fig. 19 - The effects of the board thicknesses on the measured sound insulations of the lightweight door blank.
(board, 25 mm glass wool, bitumen, board)

18 mm board is pronounced as the board has not been significantly damped. The coincidence dip at 3.15 kHz for the 12 mm board was only observed when the board was not damped. There were subtle differences between the curves near the coincidence frequencies which can be explained in terms of the thicknesses of the boards used and the choice of board to be damped. Because the use of different board thicknesses resulted in improved sound insulations between 160 – 315 Hz, it was decided that an asymmetrical construction should be used.

3.7 Bitumen damping mat on the asymmetrical door

Fig. 20 (*overleaf*) shows the effects on the measured sound insulations of the addition of a bitumen damping mat to different boards in the asymmetrical lightweight door (18 mm MDF, 25 mm cavity containing glass wool, 9 mm MDF). The two coincidence frequencies are 2.5 – 3.15 kHz (9 mm MDF) and 1.6 kHz (18 mm MDF). The addition of a damping mat to a board reduced the depth of the coincidence dip for that board. The results show that it was preferable to fit a bitumen damping mat to both boards. If, for cost or weight reasons, only one layer of



(Rw values are shown in brackets)

Fig. 20 - The effects of bitumen damping mat on the measured sound insulations of the lightweight door blank.
(18 mm MDF, 25 mm glass wool, 9 mm MDF)

damping mat was permitted, then it would be better to fit it to the 18 mm MDF because this improved the insulation at 160 Hz.

Fig. 21 shows the measured sound insulations of the 18 mm MDF – 9 mm MDF door (with bitumen damping mat fitted to the 18 mm thick MDF) compared with that of the 12 mm MDF – 12 mm MDF door. The performance of the 18 mm MDF – 9 mm MDF combination is better between 125 – 200 Hz because of the asymmetry of the door. Use of an asymmetrical door construction is very worthwhile for sound insulation reasons because the internal resonances do not coincide.

3.8 Comparison with existing BBC door blanks

Fig. 22 shows the measured sound insulations of the best lightweight air-cored door blank (18 mm MDF, bitumen, 25 mm cavity containing glass wool, bitumen, 9 mm MDF) compared with those of existing BBC door blanks. The lightweight door has

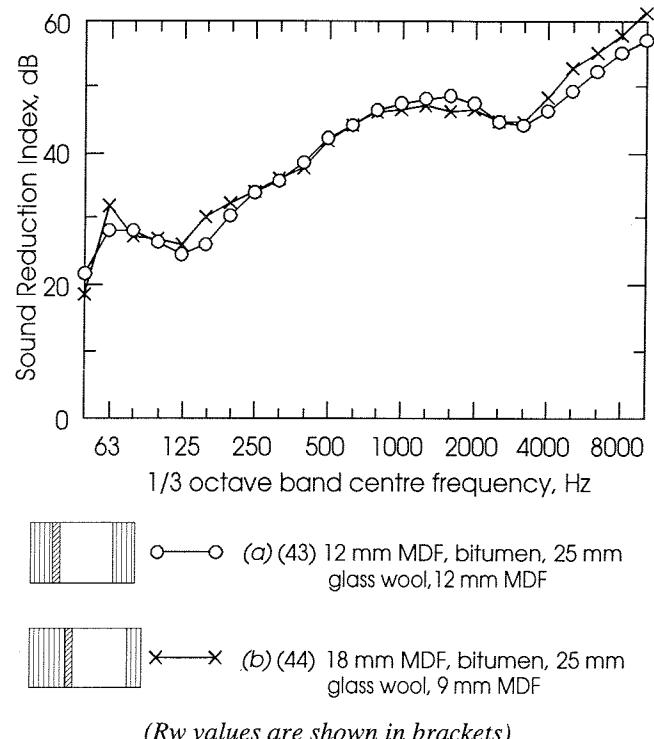
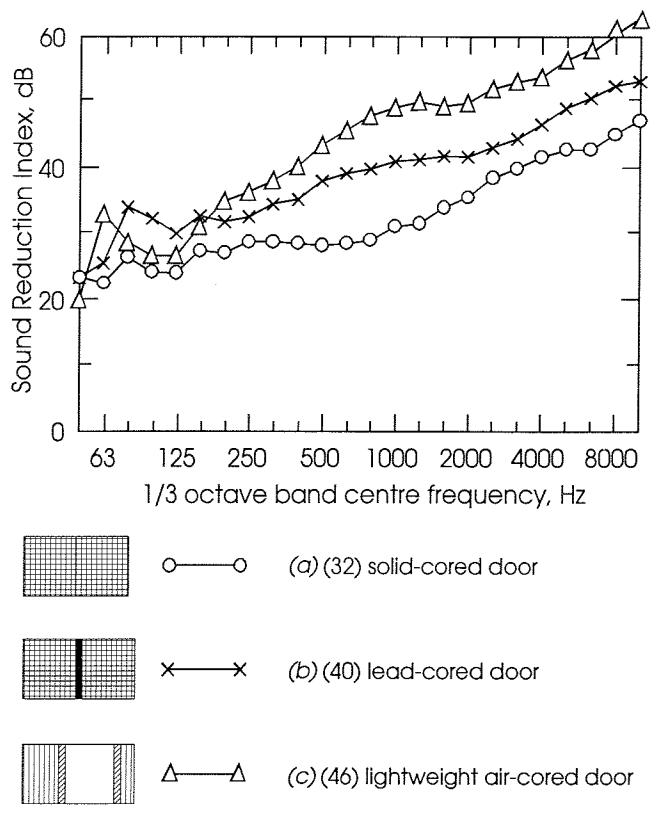


Fig. 21 - The effects of asymmetry on the measured sound insulations of the lightweight door blank.



(Rw values are shown in brackets)

Fig. 22 - The measured sound insulations of the best lightweight air-cored door blank compared with those of existing BBC door blanks.

significantly higher sound insulations than the other doors above 160 Hz. The cavity in the door accounts for the increase in the sound insulation performance at higher frequencies. The performance of the light-weight door between 80 – 160 Hz is between that of the solid-cored and lead-cored doors.

The performance of the lightweight door is very good considering the mass and the cost of the door. To reduce the cost and weight of the lightweight door further, the bitumen damping layer could be omitted from the 9 mm MDF. However, this would reduce the sound insulations below 200 Hz by approximately 1 dB. The sound insulations above 160 Hz would also decrease, which should not be important. This is because the high frequency performances would still be comparable to those of a typical single leaf partition into which the door would be built and because the achieved levels of sound insulation will, in practice, be controlled by the performances of the door seals.

4. PROPERTIES OF THE BLANKS

4.1 Costs

Shown in Table 1 are approximate materials costs for some of the door blanks with no facing or lipping. The labour costs for the construction of each of the blanks are likely to be comparable with each other.

4.2 Weights

The weights of most of the door blanks were measured. For some of the door blanks, the weights were estimated from the weights of other doors. The door blanks were of size 2.02 m × 0.95 m. The weights are shown in the Table 2.

4.3 Fire resistances

The fire resistances of most of the solid-cored doors are likely to be comparable with those of existing BBC doors. If improvements are required, fire resistant MDF could be used. The thinner skins in the air-cored door are likely to compromise the fire performance, although the glass wool will help to offset that reduction.

4.4 Stabilities

MDF is a stable material, more so than blockboard. The new doors should be less prone to distortion and warping.

Table 1: Comparative costs of the door blanks.

Description	Cost, £
BBC solid-cored door	90
BBC lead-cored door	150
25 mm MDF – bitumen – 25 mm MDF	100
18 mm MDF – bitumen – 25 mm cavity with glass wool – 9 mm MDF	85
18 mm MDF – bitumen – 25 mm cavity with glass wool – bitumen – 9 mm MDF	120

4.5 Suggested finishes

The doors could be finished with a hardwood lipping and faced with veneer as at present to give a robust finish. Instead of the veneer, the doors could be painted to reduce costs. This is unlikely to affect the acoustic performances.

Table 2: Relative weights of the door blanks.

Description	Weight, kg
BBC solid-cored door	51.9
BBC lead-cored door	96.0
BBC polymer-cored door	86.7
25 mm MDF – 25 mm MDF	72.8
25 mm MDF – bitumen – 25 mm MDF	82.9 (est)
18 mm MDF – bitumen – 25 mm cavity with glass wool – 9 mm MDF	52.3 (est)
18 mm MDF – bitumen – 25 mm cavity with glass wool – bitumen – 9 mm MDF	62.4 (est)
15 mm MDF – 15 mm MDF	43.1
15 mm MDF – bitumen – 15 mm MDF	53.2
15 mm MDF – lead – 15 mm MDF	93.5
9 mm plywood – 15 mm MDF – bitumen – 15 mm MDF – 9 mm plywood	75.5 (est)
9 mm plywood – 15 mm MDF – lead – 15 mm MDF – 9 mm plywood	115.8 (est)
30 mm plywood	37.2

5. SELECTION OF THE BEST DOORS

A number of the door blanks tested can be rejected for the following reasons. The 30 mm thick door blanks were too thin to be structurally adequate. Doors without internal damping layers suffer from coincidence dips at higher frequencies. The combination of MDF and plywood also produces undesirable coincidence dips.

The two best remaining acceptable designs are the door blank containing bitumen damping mat, surrounded by a layer of 25 mm thick MDF each side, and the air-cored door blank. The door having 25 mm thick MDF each side of bitumen has a comparable acoustic performance to that of the existing BBC lead-cored door, but it is more than 10% lighter and is made from more stable materials.

Either of the lightweight air-cored doors shown in the table of weights would be acceptable as an alternative to the conventional solid-cored door. The sound insulations of these lightweight doors are particularly good at higher frequencies. In all but the most stringent circumstances, the lightweight air-cored door containing only one layer of bitumen damping mat would be acceptable. This has a comparable weight and cost to that of the solid-cored door.

If the 9 mm thick MDF layer was considered too flexible, it could be braced internally. However, care would have to be taken to ensure that the bracing did not couple the two skins of the door together.

6. CONCLUSIONS

The existing BBC solid-cored door does not have a particularly high level of sound insulation; neither is the blockboard used in solid-cored and lead-cored BBC doors particularly stable, so the doors can warp. Doors made from MDF should be more stable, requiring less adjustment and having a longer lifespan.

Doors have been designed which are made from MDF and have comparable or better sound insulations than existing BBC doors. These doors have similar construction costs to existing BBC designs and are more stable.

7. RECOMMENDATIONS

The suggested doors should be tested in a field installation. If the doors prove to be worthwhile, fire tests may be necessary.

8. REFERENCES

1. BS8214: 1990 Code of Practice for Fire Door Assemblies with Non-metallic Leaves.
2. GILFORD, C., 1972. Acoustics for radio and television studios. Peter Peregrinus Ltd, p. 59.
3. BERANEK, L.L., 1960. Noise reduction. McGraw-Hill, p. 313.

APPENDIX I

The partition used for testing the door blanks

An estimate of the best sound insulation performance likely to be measured for a door blank showed that the test partition needed to be a double leaf masonry wall. The two leaves of the partition were independently constructed in the openings in the source and receive room walls of the Transmission Suite. One leaf was constructed from 140 mm thick Lytag blocks, having a density of 2000 kg/m³. The other leaf was constructed from 100 mm thick Lytag blocks, having a density of 1350 kg/m³. The leaves were isolated from the surrounding walls using 6 mm-thick closed-cell foam rubber sheet.

The cavity between the two leaves was filled with glass wool batts. Care was taken to ensure that the two leaves were structurally independent. The wall was rendered both sides with a 15 mm thick coat of render. After construction of the wall and measurement of its insulation, an aperture (size 1055 × 2100 mm) was knocked in the wall to receive the frame and the doors. (Concrete lintels had been built into the wall at the time of construction to support the leaves when the door opening was made.) The door and frame were built into the leaf which had been constructed from the 140 mm blocks. The exposed cavity adjacent to the frame was sealed with a flexible foam rubber seal.

APPENDIX II

The effects of sealing conditions on the results

Fig. A2.1 shows the results of a number of experiments intended to identify the best way of sealing the perimeters of the door blanks. The BBC solid-cored blank was used for these tests. With a large gap (6 mm gap) and no acoustic sealant, the sound insulations at higher frequencies were poor, as expected. All the remaining sealing conditions resulted in similar levels of sound insulation at higher frequencies. The results for a large gap (6 mm) or a small gap (3 mm) (both sealed with acoustic sealant) were comparable with each other. When the door was screwed to the frame to give a rigid bond, the sound insulation performance at lower frequencies was poor and erratic. This was because panel resonances were less damped and because vibrations were transmitted into the surrounding walls by the rigid bond. With no gap at the perimeter of the door, the performance at higher frequencies was slightly reduced because it was difficult to seal the perimeter fully with acoustic sealant. The performances at lower frequencies were also affected because the mounting conditions were more rigid.

Typical door installations use a small gap (3 mm) between the door and the frame. The use of a small gap resulted in a smooth sound insulation curve at lower frequencies and a good performance at higher frequencies, showing that the acoustic sealant was providing an effective seal. Therefore it was decided to use a small gap which was sealed with acoustic sealant for the remaining door blank tests.

Fig. A2.2 shows the effects of the acoustic sealant drying out on the measured sound insulations of a 30 mm thick MDF door blank. As the acoustic sealant dried, it became harder and provided a more rigid mechanical bond. When the acoustic sealant dried completely, the measured sound insulations between 63 Hz – 1.25 Hz decreased by 1 dB on average. All the remaining measurements were made just after sealing the gaps with soft acoustic sealant.

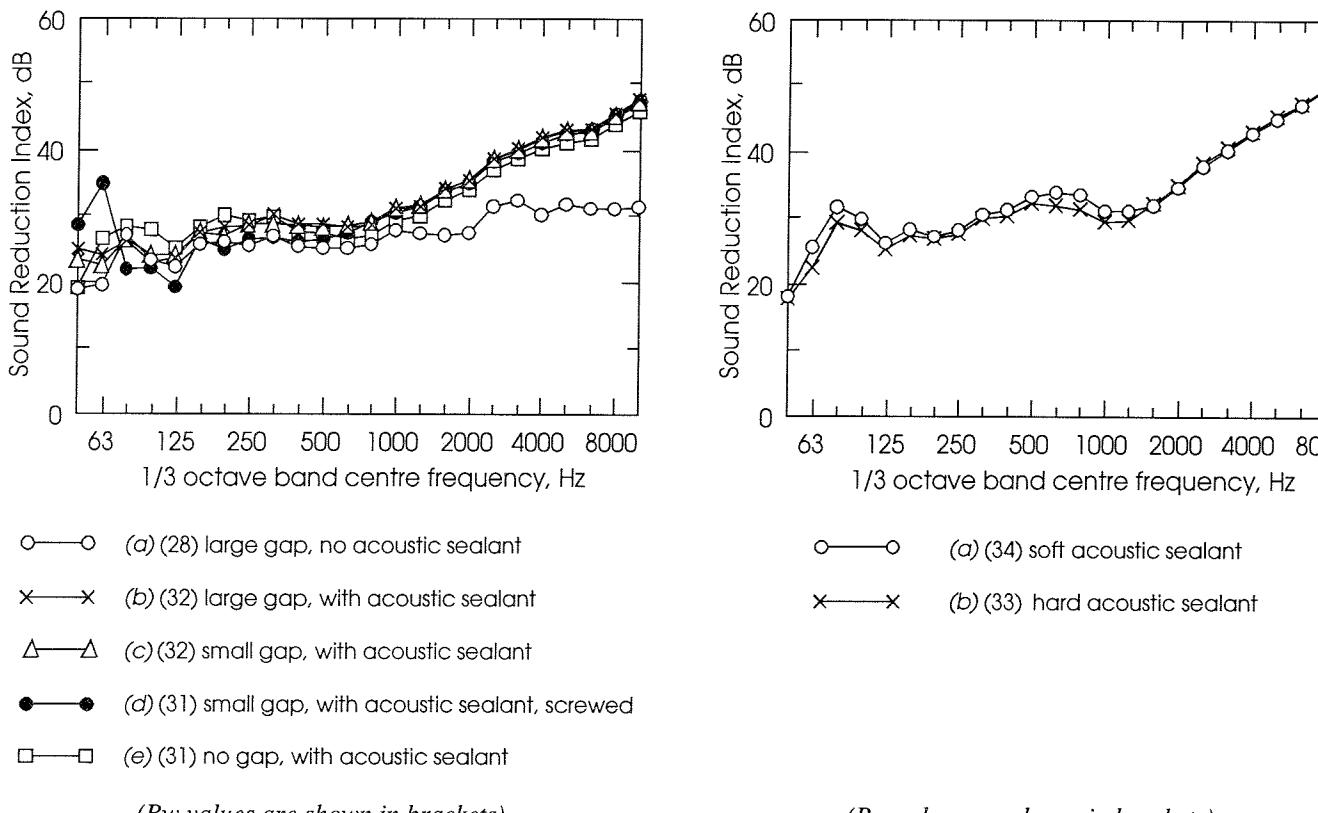


Fig. A2.1 - The effects of sealing conditions on the measured sound insulations of the BBC solid-cored door blank.

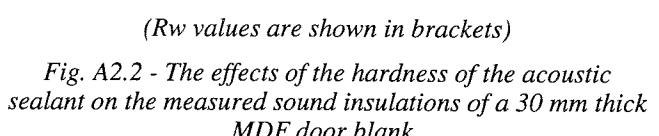


Fig. A2.2 - The effects of the hardness of the acoustic sealant on the measured sound insulations of a 30 mm thick MDF door blank.